INDOOR AIR QUALITY ASSESSMENT

Belmont Light
40 Prince Street
Belmont, MA

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
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Background/Introduction

In response to a request by Craig Spinale, Director of Operations, Belmont Light, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality (IAQ) at the Belmont Light (BL) offices located at 40 Prince Street Belmont, Massachusetts. This evaluation was conducted in response to office staff reports of indoor air quality and health concerns. On May 15, 2014, a visit to conduct an IAQ assessment was made by Sharon Lee and Jason Dustin, Environmental Analysts/Inspectors from BEH's IAQ Program. BEH/IAQ staff were accompanied by Stefan Russakow, Director, and Angela Braun, Assistant Director of the Belmont Health Department.

Built in 2000, the space is a single story, brick-faced building with a pitched, asphalt-shingled roof. The current layout includes offices, open work areas (cubicles), conference rooms, IT server room, reception area, utility room, and kitchen areas. Most areas of the building have dropped ceiling tiles and wall-to-wall carpeting. Windows in the building are openable.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor 7565. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH/IAQ staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The building currently houses approximately 20 employees. Tests were taken during normal operations, and results appear in Table 1.

Discussion

Ventilation

It can be seen that carbon dioxide levels were below 800 parts per million (ppm) in 20 out of 21 areas tested, indicating adequate air exchange in the majority of areas surveyed at the time of assessment (Table 1). Fresh air is provided by an air handling unit (AHU) located in the mechanical room (Picture 1). This AHU has a single fresh air supply vent located on the outside wall at the rear of the building (Picture 2). Once air is filtered, it is heated or cooled and delivered to occupied areas via ceiling-mounted fan coil units (Picture 3) ducted to supply diffusers (Picture 4). Return air is drawn into a ceiling plenum via vents (Picture 5) and ducted back to the AHU located in the utility room.

The heating, ventilation, and air conditioning (HVAC) system is controlled by digital thermostats. Thermostats examined had a fan switch with two settings, *on* and *auto*. When the fan is set to *on,* the system provides a continuous source of air circulation and filtration. The *automatic* setting on the thermostat activates the HVAC system at a pre-set temperature. Once the pre-set temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. At the time of assessment, all thermostat fan settings were in the "auto" position (Picture 6). As mentioned, this thermostat setting can limit airflow. The MDPH typically recommends that thermostats be set to the fan *on* setting during occupied hours to provide continuous air circulation. The fan "auto" setting can lead to IAQ/comfort complaints due to lack of air exchange.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

Minimum design ventilation rates are mandated by the Massachusetts State Building Code (MSBC). Until 2011, the minimum ventilation rate in Massachusetts was higher for both occupied office spaces and general classrooms, with similar requirements for other occupied spaces (BOCA, 1993). The current version of the MSBC, promulgated in 2011 by the State Board of Building Regulations and Standards (SBBRS), adopted the 2009 International Mechanical Code (IMC) to set minimum ventilation rates. **Please note that the MSBC is a minimum standard that is not health-based**. At lower rates of cubic feet per minute (cfm) per occupant of fresh air, carbon dioxide levels would be expected to rise significantly. A ventilation rate of 20 cfm per occupant of fresh air provides optimal air exchange resulting in carbon dioxide levels at or below 800 ppm in the indoor environment in each area measured. MDPH recommends that carbon dioxide levels be maintained at 800 ppm or below. This is because most environmental and occupational health scientists involved with research on IAQ and health effects have documented significant increases in indoor air quality complaints and/or health effects when carbon dioxide levels rise above the MDPH guidelines of 800 ppm for schools, office buildings and other occupied spaces (Sundell et al., 2011). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Indoor temperature measurements at the time of the assessment ranged from 75° F to 78° F in occupied spaces (Table 1), which were within the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to maintain comfort without operating the HVAC system as designed (i.e., deactivating units via the thermostat).

Indoor relative humidity measurements at the time of the assessment ranged from 49 to 59 percent (Table 1), which were within the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Humidity levels in the building would be expected to drop during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of water exposure is necessary. BEH/IAQ staff noted two ceiling tiles with some water staining (Picture 7). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. These areas should be monitored to ensure that leaks have been abated.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g., carpeting, gypsum wallboard) be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed/discarded.

Plants were noted in some areas (Table 1). Plants can be a source of pollen and mold, which can be respiratory irritants to some individuals. Plants should be properly maintained and equipped with drip pans and located away from air supplies to prevent the aerosolization of dirt, pollen and mold.

Water coolers and a small refrigerator were observed in carpeted areas (Picture 8). Spills or leaks from this equipment can moisten carpet and lead to microbial growth and degradation of the carpet. MDPH recommends placing rubber or plastic trays beneath this equipment to protect the carpet from any leaks.

In additional, debris that builds up in refrigerator gaskets can be a source for mold growth. All refrigerators should be cleaned regularly and if gaskets and other components cannot be adequately cleaned with an anti-microbial agent, they should be replaced.

BEH/IAQ staff noted a tree in close proximity to the rear of the building (Picture 9). It is important to keep all vegetation away from building since it may allow for moisture, pests, and pollen to enter the building.

Several downspouts were observed to be unattached at the base and allowed to empty against the base of the building. Although the area is surrounded by crushed stone, it is recommended that all downspouts be attached to a drainage system that carries water away from the building.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor, and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the indoor environment, BEH/IAQ staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health effects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 2011). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measurable levels of carbon monoxide were detected inside the building (Table 1).

Particulate Matter

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter includes airborne solids, which can result in eye and respiratory irritation if exposure occurs. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 was measured at 17 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 6 to 8 $\mu g/m^3$ (Table 1), which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in buildings can generate particulate matter during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

A variety of copying and printing devices were noted in occupied areas of the building. Of particular note is the copier room, which does *not* have a dedicated local exhaust vent. Also, areas where food is stored and heated or prepared, including coffee pots, microwaves and ovens, may all produce particulates. Areas such as these with a high potential to cause particulate emissions or odors should be located close to exhaust ventilation and away from sensitive individuals when possible.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Total volatile organic compounds (TVOCs) can result in eye and respiratory irritation if exposure occurs. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH/IAQ staff examined rooms for products containing these respiratory irritants.

Several rooms contained dry erase marker (DEM) boards and related materials (Table 1). Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Hand sanitizers were found in some offices and common areas (Table 1). Hand sanitizer products may contain ethyl alcohol and/or isopropyl alcohol, which are highly volatile and may be irritating to the eyes and nose and may contain fragrances to which some people may be sensitive.

Cleaning products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. These products should be properly labeled. Consideration should be given to working with building management to provide staff with cleaning products and supplies consistent with lease agreements to prevent any potential for adverse chemical interactions.

Other Conditions

Some staff reported symptoms such as eye and respiratory irritation during the heating season. BEH/IAQ staff examined the workspaces of these staff and observed air diffusers were located directly above the desks of these individuals (Picture 4). Heating or cooling removes moisture from air. As a result, air that is supplied through air diffusers is typically lower in humidity. As mentioned, the sensation of dryness and irritation is common in a low relative humidity environment. Relocating air diffusers or redirecting air towards a wall may reduce occupant irritant symptoms.

BEH/IAQ staff observed the sole fresh air intake vent in the rear of the building. It was reported that office staff have complained of vehicle exhaust odors in the past. This intake vent is in close proximity to a parking lot area (Picture 10) used by tree trimming vehicles under contract with BL. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1996). It is strongly recommended a buffer zone be created around this fresh air intake vent to prevent the draw of vehicle exhaust into the ventilation system of the building. This may be achieved by installing anti-idling signs in combination with physical barriers.

It was also noted that the fresh air intake vent is close to the main backup generator for the facility. It was reported that this generator is tested once weekly (Tuesday) as part of a regular maintenance schedule. MDPH recommends either scheduling the generator testing when the building is unoccupied or extending the exhaust above and/or away from the fresh air intake.

Due to the addition of a new wall, the reception area's return venting is limited to the vents located in the offices of the Director and GM. If these doors are not open, return ventilation is further limited to a return vent around the corner of the wall near the restrooms.

In some offices, a large number of items were on flat surfaces (e.g., floors, windowsills, tabletops), which provide a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for areas to be cleaned. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. In addition, dust and debris can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Dust was observed collected on air supply diffusers in a few areas (Picture 3). Dust that has collected on diffusers can be re-aerosolized when HVAC equipment is reactivated. Dust can be irritating to the eyes, nose and respiratory tract.

Food and food preparation equipment were observed in many offices and common areas. Food should be kept in tightly-sealed containers to prevent attracting pests and food preparation equipment should be kept clean and free of debris that can cause odors, smoke when heated, or attract pests.

Most areas in the offices are carpeted; the Institute of Inspection, Cleaning and Restoration Certification (IICRC) recommends that carpeting be cleaned annually (or semi-annually in soiled high traffic areas) (IICRC, 2012). Regular cleaning with a high efficiency particulate air (HEPA) filtered vacuum in combination with an annual cleaning will help to reduce accumulation and potential aerosolization of materials from the carpeting.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Redirect or relocate supply air diffusers to prevent direct impact on individuals.
2. Set thermostats to the fan "on" position to provide continuous air circulation/filtration during business hours.
3. Develop a plan to prevent vehicle exhaust from being entrained into the fresh air intake.
4. Perform weekly generator testing during a time when building is unoccupied or consider ducting generator exhaust away from fresh air intake.
5. Clean supply diffusers and return vents on a regular basis.
6. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Replace any water-damaged ceiling tiles when a leak is discovered and repaired. Staff should be encouraged to report building leaks to management for prompt remediation.

9. Provide a dedicated local exhaust vent for the copier room or relocate equipment to an area that has dedicated exhaust ventilation.

10. Consider adding a return vent for reception area due to the reconfiguration of the wall and limited return ventilation in that space should office doors be closed.

11. Attach downspouts to a drainage system that brings water *away* from the building.

12. Avoid overwatering of plants. Ensure flat surfaces around plants are free of potting soil and other plant debris. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

13. Place refrigerators and water dispensing equipment in non-carpeted areas or consider using a waterproof mat to contain spills or leaks.

14. Ensure refrigerators are cleaned out regularly. Clean moldy gaskets with a mild detergent or antimicrobial agent, if cannot be adequately cleaned consider replacing.

15. Relocate or consider reducing the amount of stored materials in offices to allow for more thorough cleaning. Move items off floors when possible. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16. Relocate items such as photocopiers, printers, paper shredders, and plants that may be in the direct airstream of supply diffusers to prevent aerosolization of particulate matter and other irritants.

17. Frequently wet wipe dry erase boards and tray to prevent particles from becoming re-aerosolized.

18. Ensure spray bottles are properly labeled. All cleaning products used at the facility should be approved, and MSDSs should be available at a central location.

19. Clean carpeting annually or semi-annually in soiled high traffic areas as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC, 2012).

20. Refer to resource manual and other related indoor air quality documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at http://mass.gov/dph/iaq.

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Picture 1

Air handling unit in mechanical room

Picture 2

Fresh air intake vent

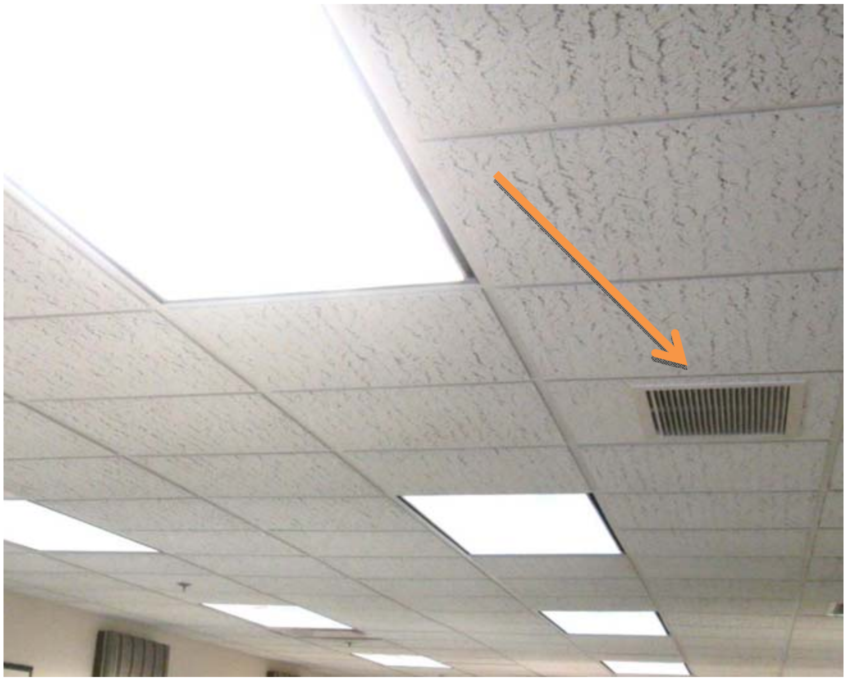
Picture 3

Fan coil unit with dust collected on supply diffuser

Picture 4

Supply air diffuser located directly above occupant's seat, note amount of items on desk

Picture 5



Return air grate

Picture 6

Thermostat fan set to "auto" mode

Picture 7

Water-damaged ceiling tiles

Picture 8

Water cooler on carpet

Picture 9

Small tree growing close to building

Picture 10

Parking area utilized by construction vehicles near fresh air intake

Location: Belmont Municipal Light **Indoor Air Results**

Address: 40 Prince St. Belmont,MA **Table 1** **Date: 5/15/2014**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background	396	ND	69	41	17					Cloudy, slight wind
Conference Room	923	ND	75	58	6	5	Y	Y	Y	MF on Carpet, WTW, WC on carpet, thermostat set to "Auto"
Customer Service:										
Rear	675	ND	77	59	7	2	Y	Y	Y	DEM, WTW, AI on surfaces
Middle	710	ND	77	58	8	0	Y	Y	Y	WC on carpet, thermostat set to "Auto"
Front	689	ND	77	58	7	4	Y	Y	Y	PC near supply vent, AI, HS, thermostat on "Auto"
Copier room	649	ND	77	57	6	0	N	Y	N	PC, printers, No local exhaust
Reception	649	ND	77	57	8	1	N	Y	N	Printer, artificial plants, return vents limited to offices or around corner of new wall
GM's Office	522	ND	76	55	6	2	Y	Y	Y	Paper Shredder, thermostat set to "Auto"
Director's Office	577	ND	75	55	7	2	Y	Y	Y	DO, DEM, plant, thermostat set to "Auto"

ppm = parts per million
μg/m³ = micrograms per cubic meter
ND = non detect
AI = accumulated items
DEM = dry erase materials
DO = door open
WC= water cooler
HS = hand sanitizer
WTW = wall to wall carpet
PC = photocopier
NC = non-carpeted
PF = personal fan
MF = mini fridge

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Women's Room									Y, Dusty	
IT Room	755	ND	76	57	8	1	Y	Y	Y	HS, printer
Servers	657	ND	50	49	6	0	Y	N	N	2 Air conditioning units to cool servers
Meter Shop	550	ND	75	57	6	1	Y	Y	Y	Printer, NC, DEM, CP, meters
Lunch Room	428	ND	75	59	8	0	Y	Y	Y	CP's under sink, NC
Electrical	466	ND	77	58	7	0	N	Y, Dusty	Y	AHU on ceiling
Mechanical	659	ND	79	58	7	0	N	Y	N	Gas boilers, Main AHU unit w/ single fresh air intake
Operations Center (CAD area)	432	ND	78	57	6	2	N	Y	Y	Plans, PC, printers, shredders, MT
Lineman's Office	432	ND	77	50	7	0	Y	Y	Y	AI on surfaces, DEM, HS, shredder, WTW
SCADA Office	461	ND	77	52	8	0	Y	Y	Y	DEM, DO, WTW

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								Supply	Exhaust	
Engineer's Office	432	ND	76	51	7	0	Y	Y	Y	HS, Bowed CT
Crew Leader Room	429	ND	76	54	8	0	N	Y	Y, Near door	NC, DEM, DO
Break Room (linemen)	412	ND	76	54	8	0	Y	Y	Y	DO, NC, PF, Water Cooler
Men's Room								Y	Y (2)	Floor drain
Women's Room								Yx2	Y (2) Dusty	

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